

Overall Objectives

- Charging station connected to 15 kV class, 1 MW
- Mitigate impact on battery degradation
- Mitigate impact on the grid

Objectives This Period

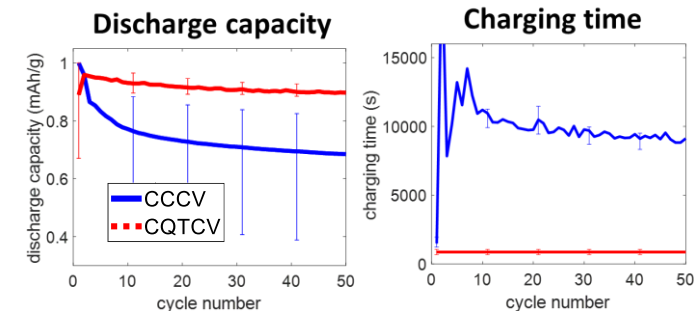
- Define topology
- Gather information on grid and battery construction
- Design and construct full-scale station

Impact

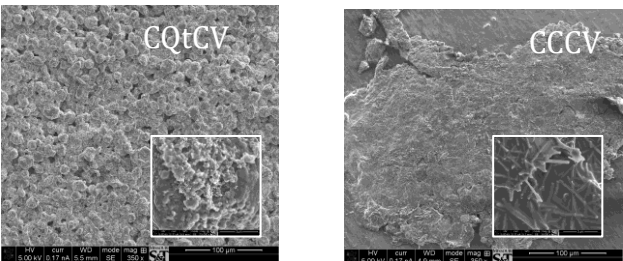
- Accelerate adoption of electric vehicles
- Provide economic benefit to charging station owner

New Charging Algorithm: CQtCV – uses degradation physics to determine optimal current

- Constant lithium plating current rather than terminal current
- Shortens charge time while reducing degradation – tunable with slope & threshold



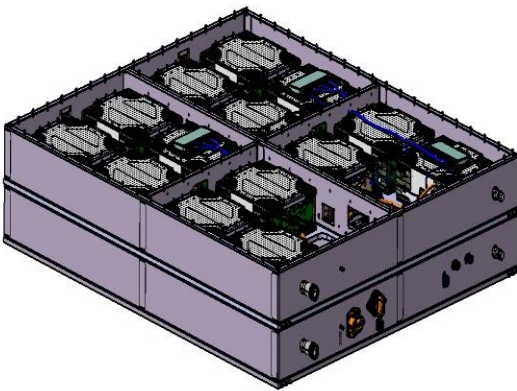
Faster Charging with Less Degradation Than CCCV



CQtCV shows almost intact electrode, but significant amount of lithium plating in CCCV

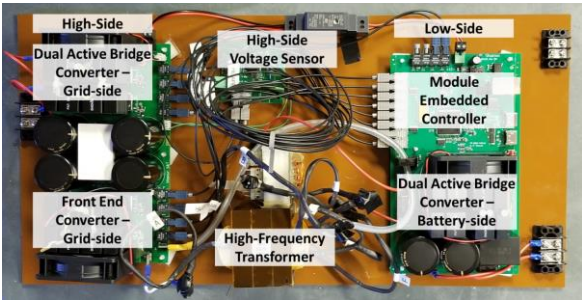
New Vehicle Pack

- Two layers of modules – requires repurposed control board, innovative cold plate, other modifications
- Slightly oversized to minimize degradation during the project testing
- Automotive-qualified components where available; otherwise designed to meet requirements
- Same pack to be used as BESS



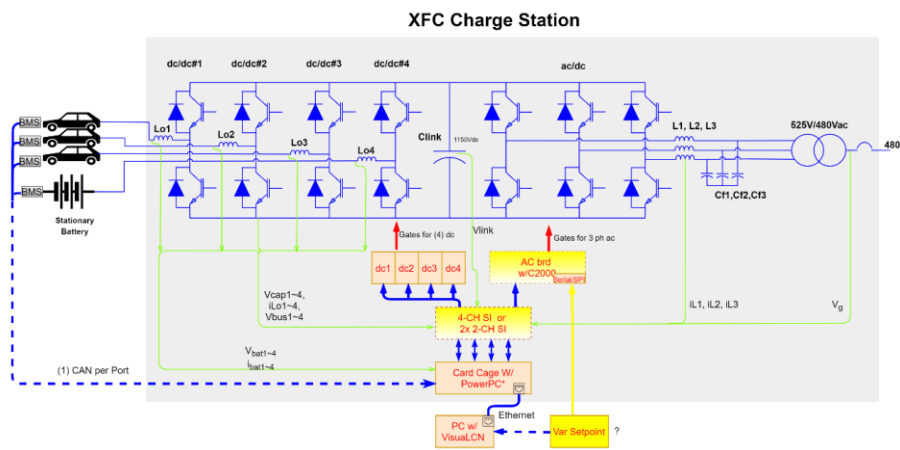
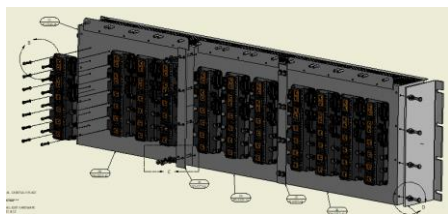
Low-Voltage, Low-Power Prototype

- Developed to support large number of modules, to prove out the control technology
- Proof-of-concept uses 2 of these modules per phase



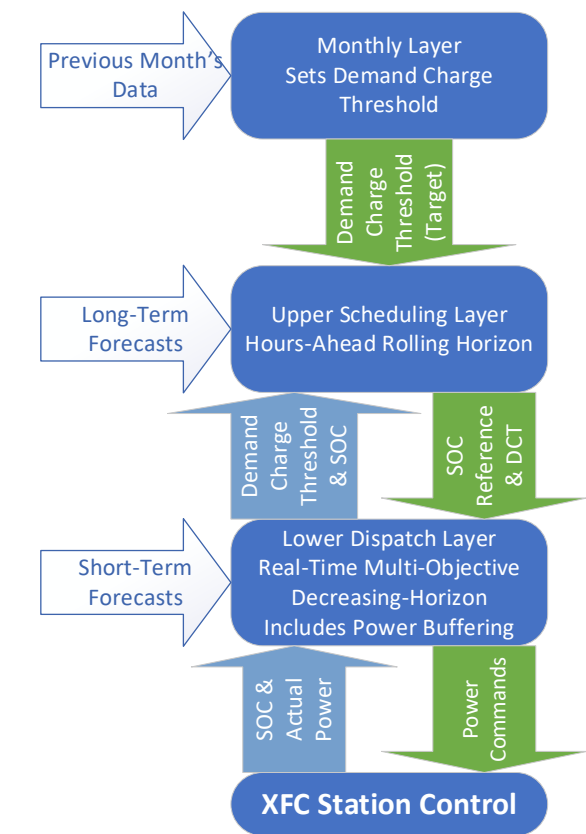
Full-Power Prototype

- Modification of existing product
 - change 2-port to 4-port;
 - add VAR control
- Also uses new IGBTs (PrimePACK)



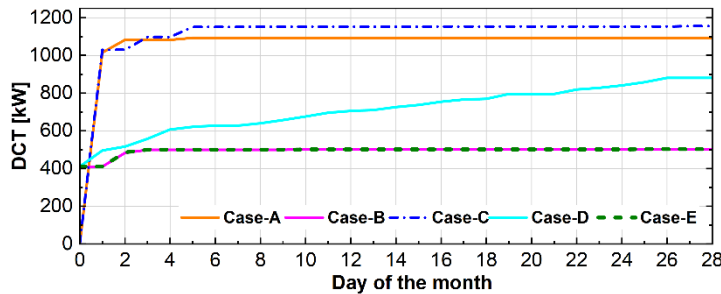
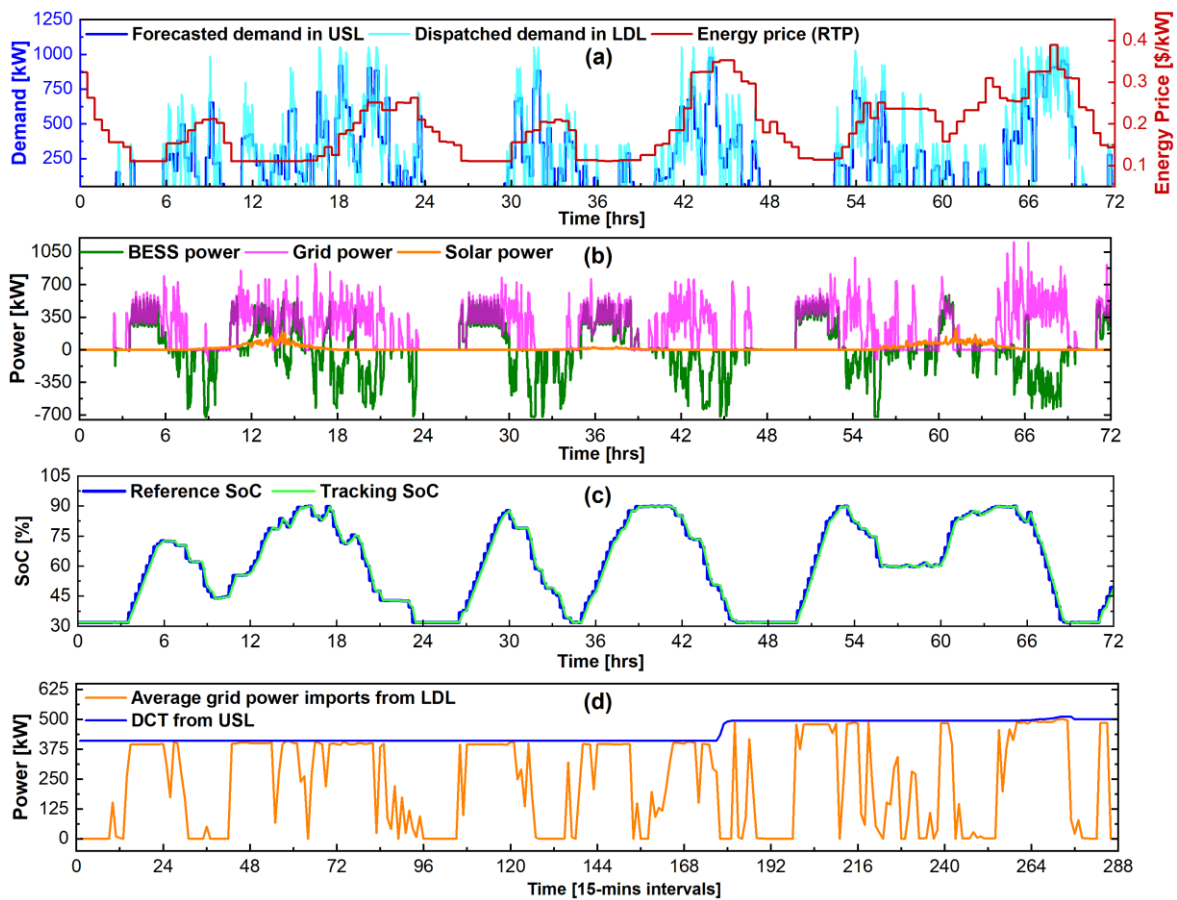
Grid Interface: Power & Energy Optimization

- Multi-tiered algorithm: monthly, hourly, and real-time optimization
- Incorporates PV forecasts, load forecasts, and battery degradation



Demand Charge Threshold Results →

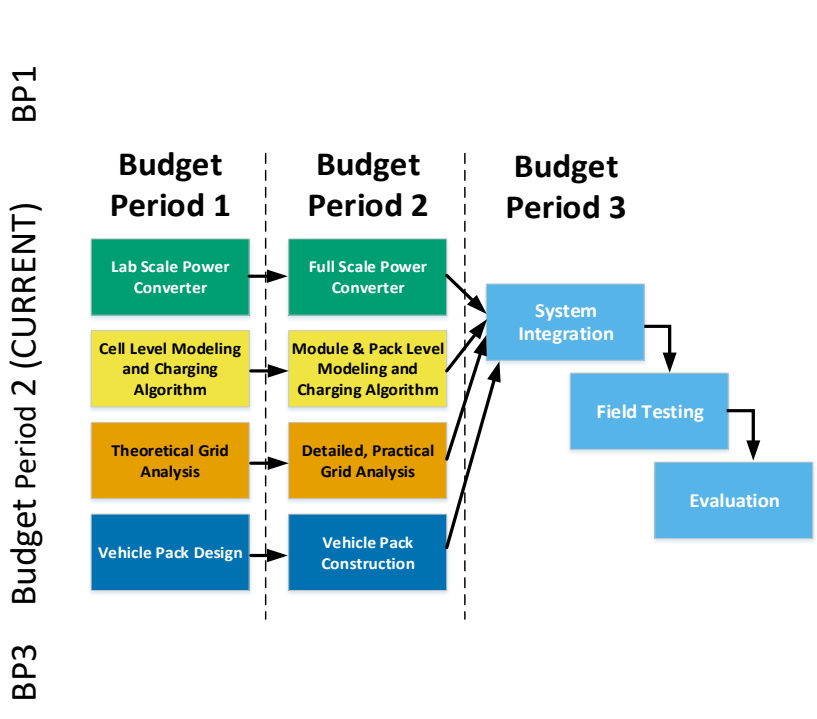
- Case-A: Unmanaged XFCS demand case
- Case-B: Without considering BESS life degradation
- Case-C: Without considering demand charges reduction – a two-layer EMS from literature
- Case-D: Without modeling the lower dispatch layer
- Case-E: Proposed Framework (Complete)



Timeline	Barriers Addressed
Start: October 1, 2018 End: September 30, 2023 60% Complete Currently in Budget Period 2 Ends September 30, 2022	Power conversion – how to ensure safe, reliable operation on medium-voltage feeder? Battery degradation – how to ensure that high charge rates do not lead to premature wearout or catastrophic failure? Grid interface – how to ensure that the station does not disrupt grid operations? Can we enhance performance?
Budget	Partners
Total Budget: \$5,831,079 DOE Share: \$2,915,377 Contractor: \$2,915,703 Current: \$2,145,722	Ameren – Investor-Owned Utility Bitrode – Battery Test Equipment Manufacturer LG Energy Solution – Battery Cell & Pack Manufacturer

BP2 Milestone	Type	Description
Battery Models Scaled Up	Technical	Battery cell models extended to module and pack level
Subsystems Ready for Integration	Technical	Low-level distributed controller complete; AFE, dc-dc, chargers individually built & tested
Module Tests Complete	Technical	First charge cycling test complete on battery modules to validate charge algorithm and model
Integrated Converter Complete	Technical	All major power converter subsystems integrated and tested
Full-Scale System Go/No-Go	Go/No-Go	Power converter, charging algorithms, ESS, and high-level grid interface control all ready for final integration and field test

- Complete subscale development, cell-level modeling, grid initial study → COMPLETE
- Scale up power converter
- Develop module- and pack-level charging algorithms
- Complete detailed grid analysis and design controller that mitigates impact, provides revenue
- Vehicle battery pack design and construction
- System integration and field testing



Summary and Future Work

- Energy and power management algorithm have been proven in simulation to mitigate voltage dips and reduce cost; voltage regulation to be implemented in hardware
- New CQtCV charging algorithm reduces charging time while reducing degradation; proven in cells, to be proven in modules & packs
- Low-voltage prototype constructed, being tested
- Full-power prototype designed, being constructed
- New vehicle test pack designed, being constructed

On Track for Full Testing in FY2023